UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site ID: R036XC102NM

Site Name: Gravelly

Precipitation or Climate Zone: 12 to 16 inches

Phase:

PHYSIOGRAPHIC FEATURES

Narrative:

This site occurs on nearly level to moderately sloping alluvial fans and upland slopes. Slopes average less than 15 percent. This site is frequently dissected by shallow, dry washes and is found at elevations ranging from about 5,000 to 6,800 feet above sea level.

Land Form:

1. Alluvial fan
2.
3.

Aspect:

1. N/A
2.
3.

	Minimum	Maximum
Elevation (feet)	5,000	6,800
Slope (percent)	0	15
Water Table Depth (inches)	N/A	N/A

Flooding:	**Minimum**	**Maximum**
Frequency	N/A	N/A
Duration	N/A	N/A

Ponding:	**Minimum**	**Maximum**
Depth (inches)	N/A	N/A
Frequency	N/A	N/A
Duration	N/A	N/A

Runoff Class:

Negligible to medium.

CLIMATIC FEATURES

Narrative:

Average annual precipitation varies from about 12 inches to just over 16 inches. Substantial fluctuations from year to year are common, ranging from a low of about 6 inches to a high of over 30 inches. Approximately one-half of the annual precipitation comes in the form of rainfall during the months of July, August, and September, although wintertime precipitation in the form of snow, sleet, or rain is sometimes significant. Spring and late fall months are normally dry.

The average frost-free period ranges from about 165 to 190 days and extends from approximately the third or fourth week in April to mid October. Average annual air temperatures are about 56 degrees F. Summer maximums can exceed 100 degrees F and winter minimums on occasion go below zero. Monthly mean temperatures generally exceed 70 degrees F for the period of June through August.

Growing conditions favor warm-season perennial vegetation, although late winter and late summer precipitation is adequate to foster a significant cool-season component in the potential plant community. Occasional wet springs also create good conditions for annual forb production, but frequent winds from the west and southwest are common during this time of year and tend to deplete soil moisture at a critical time for the growth of these plants.

Climate data was obtained from http://www.wrcc.sage.dri.edu/summary/climsmnm.html web site using 50% probability for freeze-free and frost-free seasons using 28.5 degrees F and 32.5 degrees F respectively.

	Minimum	Maximum
Frost-free period (days):	125	187
Freeze-free period (days):	146	211
Mean annual precipitation (inches):	12	16

Monthly moisture (inches) and temperature (^{0}F) distribution:

	Precip. Min.	Precip. Max.	Temp. Min.	Temp. Max.
January	.37	1.22	16.2	55.6
February	.35	.94	18.6	60.1
March	.26	.95	22.1	66.1
April	.26	.42	27.0	74.2
May	.12	.58	34.0	82.6
June	.53	.98	42.8	92.0
July	2.29	3.32	52.5	92.6
August	2.50	3.22	51.4	89.9
September	1.62	2.85	43.5	85.7
October	1.17	1.81	32.0	76.2
November	.41	1.58	22.0	64.4
December	.61	1.85	15.9	55.9

Climate Stations:

				Period		
Station ID	299806	Location	Chloride Ranger Stn., NM	From: 05/14/49	To:	12/31/00
Station ID	291910	Location	Cliff 11SE, NM	From: 01/01/37	To:	12/31/00
Station ID	294009	Location	Hillsboro, NM	From: 10/01/24	To:	12/31/00
Station ID	297386	Location	Hood Ranger Stn., NM	From: 04/01/54	To:	12/31/00
Station ID	298324	Location	Silver City, NM	From: 01/01/61	To:	12/31/00

INFLUENCING WATER FEATURES

Narrative:

This site is not influenced by water from a wetland or stream.

Wetland description:

System	Subsystem	Class
N/A		

If Riverine Wetland System enter Rosgen Stream Type:

N/A

REPRESENTATIVE SOIL FEATURES

Narrative:

The soils that characterized this site are gravelly and very gravelly and deep to shallow. They have water intake rates that are moderate to high if vegetative cover is adequate. They are usually, but not always, noncalcareous to slightly calcareous at the surface, with varying amounts of carbonates found in the subsoils.

Parent Material Kind: Alluvium
Parent Material Origin: Mixed

Surface Texture:

1. Very gravelly loam
2. Very gravelly fine sandy loam
3. Gravelly loam
4. Gravelly sandy loam
5. Very cobbly loam
6. Gravelly clay loam
7. Gravelly sandy clay loam
8. Cobbly loam
9. Gravelly fine sandy loam
10. Very gravelly clay loam
11. Very gravelly sandy loam

Surface Texture Modifier:

1. Gravel
2. Cobble
3.

Subsurface Texture Group: Clayey
Surface Fragments <=3" (% Cover): 15 to 60
Surface Fragments >3" (% Cover): 15 to 60

Subsurface Fragments <=3" (%Volume): 4 to 57
Subsurface Fragments >=3" (%Volume): 1 to 3

	Minimum	Maximum
Drainage Class:	Well	Well
Permeability Class:	Impermeable	Moderately rapid
Depth (inches):	16	60
Electrical Conductivity (mmhos/cm):	0.00	4.00
Sodium Absorption Ratio:	N/A	N/A
Soil Reaction (1:1 Water):	6.1	9.0
Soil Reaction (0.1M CaCl2):	N/A	N/A
Available Water Capacity (inches):	1	6
Calcium Carbonate Equivalent (percent):	N/A	N/A

PLANT COMMUNITIES

Ecological Dynamics of the Site:

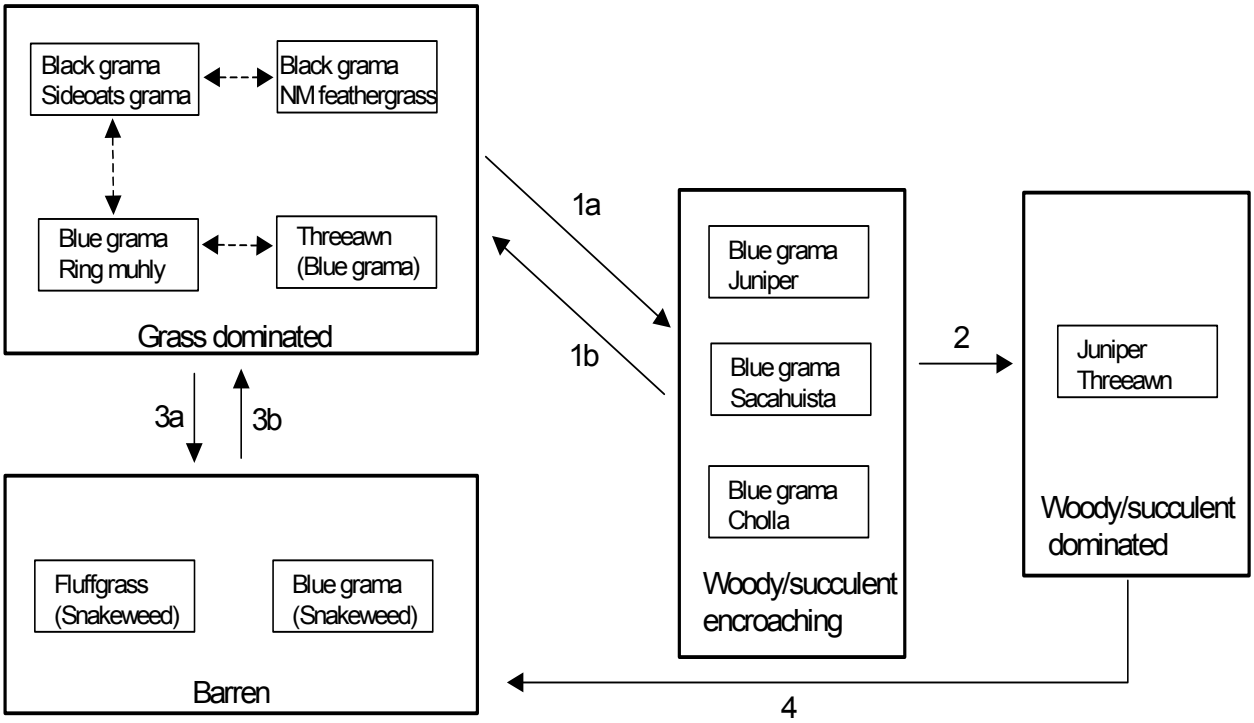
Overview

Gravelly sites occur in association with hills and breaks sites. The historic community type of the gravelly site is dominated by black grama (Bouteloua eriopoda), New Mexico feathergrass (Stipa neomexicana), and sideoats grama (Bouteloua curtipendula). Yuccas (Yucca sp.), sacahuista (Nolina spp.), winterfat (Krascheninnikovia lanata), or mariola (Parthenium incanum) may also occur. Blue grama (Bouteloua gracilis) and hairy grama (B. hirsuta) are common. Under heavy grazing pressure and/or drought, blue and hairy grama, wolftail (Lycurus spp.), threeawns (Aristida spp.) and Hall's panicum (Panicum halli) may increase in representation as grass cover declines. Reduced competition from grass, a decline in fire frequencies with or without a loss of grass cover, or perhaps regional increases in the relative amount of winter rainfall may lead to significant increases in the abundance of woody plants and succulents, usually one-seed juniper (Juniperus monosperma) as well as sacahuista (Nolina spp.) and shrub liveoak (Quercus spp.). The presence of gravelly soils at the bases of hills dominated by juniper may increase the likelihood of juniper invasion of gravelly sites relative to other sites. Juniper competes with grasses and may lead to persistent reductions in grass abundance. Subsequent erosion (in some cases) may retard the capacity of grasses to reestablish following woody plant removal.

No systematic studies of communities, states or transitions have been performed in the gravelly site.

Plant Communities and Transitional Pathways (diagram)

State-Transition model: MLRA 36, WP-3, Gravelly site group: Gravelly



1a. Heavy grazing, summer drought, reduced cover, decreased fire
1b. Clearing, seeding, increased fire frequency
2. Continued encoachment, erosion and loss of soil fertility from interspaces
3a. Severe overgrazing, erosion, loss of soil fertility
3b. Erosion control, gully destruction, seeding
4. Clearing after erosion has occurred

MLRA 36; WP-3; Gravelly

Woody-succulent encroaching state

- Mesquite present
- Black grama present, low cover
- Drought-induced mortality common

Plant Community Name: Historic Climax Plant Community

Plant Community Sequence Number: 1 **Narrative Label**: HCPC

Plant Community Narrative: Historic Climax Plant Community

State Containing the Historic Climax Plant Community:

Grassland State: Black grama and sideoats grama are consistent dominants in sustainably-grazed grasslands, with New Mexico feathergrass cover fluctuating with variation in winter-spring precipitation. Grass and forb cover is near 24% and over half of the ground cover is gravel or bare soil. Retrogression caused by heavy grazing leads to increases in bare ground and increasing representation of blue grama, ring muhly (Muhlenbergia torreyi), and wolftail. At high grazing pressures or in harsh conditions, threeawns often dominate. Green sprangletop (Leptochloa dubia), cane bluestem (Bothriochloa barbinodis), plains bristlegrass (Setaria leucopila), and bottlebrush squirreltail (Elymus elymoides) are often eliminated by heavy grazing. Under current climate, fire is probably necessary to maintain this state (thus the grassland may be a disclimax; Johnsen 1962).

Diagnosis: Black grama is dominant or co-dominant with sideoats grama and sometimes New Mexico feathergrass. Bare patches are small (> 0.5 m) and infrequent, as are signs of erosion.

Canopy Cover:	
Trees	0
Shrubs and half shrubs	5 %
Ground Cover (Average Percent of Surface Area).	
Grasses & Forbs	24
Bare ground	3
Surface gravel	50
Surface cobble and stone	3
Litter (percent)	20
Litter (average depth in cm.)	2

Plant Community Annual Production (by plant type):

Annual Production (lbs/ac)

Plant Type	Low	RV	High
Grass/Grasslike	468	786	1,105
Forb	44	74	104
Tree/Shrub/Vine	44	74	104
Lichen			
Moss			
Microbiotic Crusts			
Total	550	925	1,300

Plant Community Composition and Group Annual Production:

Plant Type - Grass/Grasslike

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production
1	BOER4	Black Grama	278 – 324	278 – 324
2	HENE5	New Mexico Feathergrass	93 – 185	93 – 185
3	BOCU	Sideoats Grama	93 – 139	93 – 139
4	BOGR2 BOHI2	Blue Grama Hairy Grama	46 – 93	46 – 93
5	SEVU2 PAHA LYPH	Plains Bristlegrass Hall's Panicum Wolftail	46 – 93	46 – 93
6	SPCR ARIST MUTO2 PLMU3	Sand Dropseed Threeawn spp. Ring Muhly Tobosa	46 – 74	46 – 74
7	BOBA3 LEDU ERIN ELEL5	Cane Bluestem Green Sprangletop Plains Lovegrass Bottlebrush Squirreltail	9 – 46	9 – 46
8	2GRAM	Other Grasses	9 – 28	9 - 28

Plant Type - Forb

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production
9	ERIOG SEFLF VEPO4 PYRRO SEAR8 OXSES	Wild Buckwheat Threadleaf Groundsel Lemon Verbena Goldenweed spp. Desert Senna Locoweed spp.	9 – 46	9 – 46
10	2FA	Other Annual Forbs	9 – 28	9 – 28
11	2FP	Other Perennial Forbs	9 – 28	9 - 28

Plant Type – Tree/Shrub/Vine

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production
12	YUEL	Soaptree Yucca	9 – 28	9 – 28
13	NOMI	Sacahuista	9 – 46	9 – 46
14	DAFO	Feather Dalea	9 – 46	9 - 46
	KRLA	Winterfat		
	PAIN2	Mariola		
	EPVI	Mormon-tea		
	FAPA	Apacheplume		
	GUSA2	Broom Snakeweed		

Plant Type - Lichen

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production

Plant Type - Moss

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production

Plant Type - Microbiotic Crusts

Group Number	Scientific Plant Symbol	Common Name	Species Annual Production	Group Annual Production

Plant Growth Curves

Growth Curve ID **0602NM**

Growth Curve Name: **HCPC**

Growth Curve Description: **Mixed warm/cool-season grassland with scattered half-shrubs.**

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0	0	5	7	10	15	25	25	8	5	0	0

ADDITIONAL STATES

Transition to woody/succulent-encroaching state (1a): The reduction of grass cover and fine fuels due to grazing, or changes in fire frequency and/or climate independent of changes in grass cover, may facilitate the establishment of juniper or other woody/succulent adults by reducing disturbance rates. The formation of bare ground patches due to grazing may also decrease competition by grass for water and facilitate establishment. These mechanisms probably work in tandem (Johnsen 1962, Gottfreid et al. 1995). Finally, livestock may increase rates of juniper seed dispersal into grasslands, although seed dispersal by native birds and mammals is probably sufficient for juniper establishment (Johnsen 1962).

Key indicators of approach to threshold: Decreased fire frequency, increases in bare ground, decreases in litter cover and grass cover, the presence and growth of tree/cactus seedlings.

Transition to barren state (3a): Heavy grazing, persistent reductions in grass cover, and associated erosion causes this transition.

Key indicators of approach to threshold: Reduction in grass cover, increases in the size and frequency of bare patches, reduction in soil stability, pedestalling of grasses.

Woody/succulent encroaching: Grass cover is often reduced and sacahuista plants increase in density or oak or juniper species invade. Mesquite (Prosopis glandulosa) may invade at lower elevations. Cholla may also invade. It is unclear why different species encroach or invade in different situations, but it is likely due to differences in soils, aspect, dispersal pathways, and elevation within this site. West of Silver City, sacahuista encroachment seems to be more common. Vegetation under mature tree canopies is usually sparse. Much of the erosion from bare intercanopy patches is usually intercepted by vegetated patches downslope within this state. Fire must be applied to maintain this state.

Diagnosis: Cover of shrubs, succulents, and/or trees exceeds 20% and grass cover is interrupted by large (> 1 m) bare patches associated with shrub or tree-dominated patches.

Transition to woody/succulent-encroaching state (2): Continued fire suppression and/or reduced fuel loads allows the development of mature trees. Over time, competitive exclusion of grasses by trees (amplified by grazing disturbance) increases bare ground to a second threshold (that defines the woodland state) beyond which erosion rates may increase rapidly (Davenport et al. 1998). Generally, the probability of crossing this threshold is greater on more erodible soils and steeper slopes. Loss of organic matter, decreased infiltration, and changes to soil structure inhibit the subsequent reestablishment of grasses.

Key indicators of approach to threshold: Increasing size and density of trees, reduction in grass cover, increases in the size and frequency of bare patches, reduction in soil stability, pedestalling of grasses.

Transition to grass-dominated state (1b): Tree removal (cabling, grubbing, or herbicides) or shrub removal followed by management of grazing to maintain continuous ground cover and maintenance of fuel levels to facilitate fire.

Woody/succulent dominated: This state is characterized by severely reduced grass cover (mostly threeawns or blue grama) and moderate to high tree densities (e.g. 100-250 trees/acre). Fuel loads may be too low and trees too large to support fire management. Juniper root systems may monopolize soil water additions. Grass tends to be organized as patches separated by large bare areas. Erosion from bare patches may be extreme and resources may not be intercepted by local vegetation patches.

Diagnosis: Grasses are isolated as patches, if present, and bare areas are continuous. Shrubs, trees, or succulents are the dominant vegetation.

Transition to barren state (4): The removal of junipers via cabling and/or herbicides would produce a barren state if soil degradation inhibited the recovery of grasses.

Barren: Grass cover is very low, dominated either by fluffgrass (Dasyochloa pulchella) or blue grama. Snakeweed (Xanthocephalum spp.) may be common depending upon climatic conditions. Erosion rates are high and probably similar to that of the Woody-succulent dominated state, although the cover of trees or succulents is low in this state. Stable barren conditions are rare in WP-3 and are more likely to occur at lower elevations near the transition to SD-2.

Diagnosis: Bare ground is interconnected, evidence of erosion is abundant. Blue grama or fluffgrass is the dominant perennial vegetation.

Transition to barren state (3b): Additions of structures (e.g. terraces) that reduce erosion rates and facilitate increases in infiltration and soil fertility could be used to catalyze recovery of perennial grass-dominated communities over a period of decades.

Information sources and theoretical background: Communities, states, and transitions are based upon information in the ecological site description and observations by Gene Adkins and Bill Schwebke, NRCS.

Several hypotheses are represented in the explanations for transitions at this site. For juniper invasion thresholds, the favored hypothesis is the fire hypothesis. This holds that frequent fires prevent tree establishment or growth to maturity in healthy grasslands. Fire-free periods of 85-90 years may result in the development of mature juniper woodlands (Tirmenstein 1989 and references therein). If fine fuels produced by grass are reduced below a threshold amount, there may be insufficient fuel to carry fire, or insufficient heat from fire to kill trees or shrubs. According to this hypothesis, trees are better competitors than grasses and can come to dominate grasslands without disturbance (Johnsen 1962). The competition, fire and climate hypotheses may be complementary.

The competition hypothesis holds that grassland maintenance depends upon the competitive exclusion of tree seedlings due to limitations in water or nutrients (Johnsen 1962). There may be a threshold grass density below which the probability of juniper establishment increases rapidly, leading to a transition to the woodland state. Junipers compete with grasses directly for water in shallow soil layers in intercanopy areas (Breshears et al. 1997) and juniper removal prior to soil loss can result in dramatic recovery of grass cover (e.g. Aro 1971). Dispersal limitation of junipers to grasslands is believed to have been historically unimportant.

The climate hypothesis holds that the current advance of junipers throughout the west is a natural part of long-term cycle of advances and retreats due to fluctuating climate. Belsky (1996) points

out, however, that the current advance (during a dry phase) is not consistent with recorded advances during wet phases. Changes in the seasonality of precipitation to wetter winters, however, may be an important factor because junipers are C3 plants. The competition, fire and climate hypotheses may be complementary.

Once junipers become established, the erosion hypothesis holds that persistent reduction in grass and litter cover, perhaps in conjunction with trampling, will eventually lead to persistent changes in soil fertility or structure that prohibit the capacity of grasses to reestablish (Allen 1989). Furthermore, erosion degrades the ability of grasses to resist erosion due to pedestalling and increasing environmental harshness to grass, leading to accelerated erosion in a positive feedback (Allen 1989, Gottfried et al. 1995). Soil erosion levels may be highly variable within an area due to soil texture, slope, and land use, thus the ability to recover grasslands upon removal of competing junipers is also variable (Davenport et al. 1999).

ECOLOGICAL SITE INTERPRETATIONS

Animal Community:

Habitat for Wildlife:

This site provides habitat which can support a resident animal community characterized by pronghorn antelope, black-tailed jackrabbit, Merrian's kangaroo rat, white-throated woodrat, white-footed mouse, badger, hog-nosed skunk, meadowlark, loggerhead shrike, Scott's oriole, scaled quail, Chihuahuan whiptailed lizard, prairie spadefoot toad, prairie rattlesnake, and striped whipsnake.

Where arroyo cutbanks occur, rock wrens nest and white-footed mouse burrow.

Hydrology Functions:

The runoff curve numbers are determined by field investigations using hydrologic cover conditions and hydrologic soil groups.

Hydrologic Interpretations	
Soil Series	**Hydrologic Group**
Abrazo	D
Datil	B
Dean	B
Golddust	C
Gustspring Rocky	C
Ildefonso	B
Ladron	B
Luzena	D
Magdalena	D
Muzzler	D
Oro Grande	D
Paymaster	B
Santa Fe	D
Scholle	B
Sedillo	B
Tesajo	B

Recreational Uses:

This site offers potential for horseback riding, nature observation, and hunting for pronghorn antelope and scaled quail. When favorable spring moisture conditions occur, a colorful display of wildflowers may be seen.

Wood Products:

This site has no significant value for wood products.

Other Products:

Grazing:

This site is suitable for grazing in all seasons of the year. Although most of the herbage is produced during the summer months, green forage in the form of forbs and cool-season grasses is produced in significant amounts during the spring months whenever moisture is adequate.

This site is adapted for cattle, sheep, and horses, generally without regard to class of livestock or season of use, although the cool-season grasses (primarily New Mexico feathergrass) tend to disappear in the event of continuous, year-long grazing by any of these animals. As advanced retrogression occurs, such plants as sacahuista, blue grama, ring muhly, broom snakeweed, and sometimes oak brush tend to take over the site, replacing black grama, New Mexico feathergrass, and sideoats grama. The site does, however, recover reasonably well under good grazing management except when woody plants have invaded or increased to the point that brush control is required.

Other Information:

Guide to Suggested Initial Stocking Rate Acres per Animal Unit Month

Similarity Index	Ac/AUM
100 - 76	2.7 – 3.6
75 – 51	3.3 – 6.0
50 – 26	5.7 – 9.5
25 – 0	9.5+

Plant Part	Code	Species Preference	Code
Stems	S	None Selected	NS
Leaves	L	Preferred	P
Flowers	F	Desirable	D
Fruits/Seeds	F/S	Undesirable	U
Entire Plant	EP	Not Consumed	NC
Underground Parts	UP	Emergency	E
		Toxic	T

Plant Preference by Animal Kind:

Animal Kind: Livestock
Animal Type: Cattle

Common Name	Scientific Name	Plant Part	Forage Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
Black Grama	Bouteloua eriopoda	EP	P	P	P	D	D	D	D	D	D	D	P	P
New Mexico Feathergrass	Hesperostipa neomexicana	EP	D	D	P	P	P	D	D	D	D	D	D	D
Sideoats Grama	Bouteloua curtipendula	EP	P	P	P	P	P	P	P	P	P	P	P	P
Winterfat	Krascheninnikovia lanata	EP	D	D	P	P	P	P	P	P	D	D	D	D
Green Sprangletop	Leptochloa dubia	EP	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Plains Bristlegrass	Setaria vulpiseta	EP	D	D	D	D	P	P	P	P	P	D	D	D

Animal Kind: Wildlife
Animal Type: Antelope

Common Name	Scientific Name	Plant Part	Forage Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
Wild Buckwheat	Eriogonum spp.	EP	U	U	D	D	D	D	D	D	U	U	U	U
Winterfat	Krascheninnikovia lanata	EP	D	D	D	D	D	D	D	D	D	D	D	D
Verbenas	Verbena polystacchya	EP	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
Other Forbs	Various	EP	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S

SUPPORTING INFORMATION

Associated sites:

Site Name	Site ID	Site Narrative

Similar sites:

Site Name	Site ID	Site Narrative

State Correlation:

This site has been correlated with the following sites: _____

Inventory Data References:

Data Source	# of Records	Sample Period	State	County

Type Locality:

State: **New Mexico**

County: **Grant, Catron, Hidalgo, Sierra, Socorro**

Latitude: _____

Longitude: _____

Township: _____

Range: _____

Section: _____

Is the type locality sensitive? **Yes** ☐ **No** ☐

General Legal Description: _____

Relationship to Other Established Classifications:

Other References:

Data collection for this site was done in conjunction with the progressive soil surveys within the New Mexico and Arizona Plateaus and Mesas 36 Major Land Resource Area of New Mexico. This site has been mapped and correlated with soils in the following soil surveys: Socorro, Sierra, Grant, Catron.

Characteristic Soils Are:	
Scholle	Ildefonso
Other Soils included are:	
Abrazo, Datil, Dean, Golddust	Gustspring Rocky, Ladron, Luzena, Magdalena
Muzzler, Nehar, Oro Grande, Paymaster	Santa Fe, Sedillo, Tesajo

Allen, C. D. 1989. Changes in the landscape of the Jemez Mountains, New Mexico. Ph.D. Dissertation. University of California, Berkeley., Berkeley, CA.

Aro, R. S. 1971. Evalutation of pinyon-juniper conversion to grassland. Journal of Range Management 24: 188-197.

Breshears, D.D., O. B. Myers, S. R. Johnson, C. W. Meyer, and S. N. Martens. 1997. Differential use of spatially heterogeneous soil moisture by two semiarid woody species: *Pinus edulis* and *Juniperus monosperma*. Journal of Ecology 85: 289-299.

Belsky, A. J. 1996. Viewpoint: Western juniper expansion: Is it a threat to arid northwestern ecosystems? Journal of Range Management 49: 53-59.

Davenport, D. W., D. D. Breshears, B. P. Wilcox, and C. D. Allen. 1998. Viewpoint: Sustainability of piñon-juniper ecosystems—a unifying perspective of soil erosion thresholds. Journal of Range Management 51: 231-240.

Gottfried, G. J., T.W. Swetnam, C. D. Allen, J.L. Betancourt, and A. L. Chung-MacCoubrey. 1995. Pinyon-juniper woodlands. p. 95-131. In D. M. Finch and J. A. Tainter (eds.) Ecology, diversity, and sustainability of the middle Rio Grande Basin. USDA Forest Service General Technical Report RM-GTR-268. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Johnsen, T. N., Jr. 1962. One-seed juniper invasion of northern Arizona. Ecological Monographs 32: 187-207.

Tirmenstein, D. A. 1989. Juniperus monosperma. In U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2001, October). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/

Site Description Approval:

Author	Date	Approval	Date
Don Sylvester		Durwood E. Ball	04/29/80

Site Description Revision:

Author	Date	Approval	Date
Elizabeth Wright	07/05/02	George Chavez	12/17/02
Dr. Brandon Bestelmeyer	04/02/03		